REMARKS

Claims 1, 2, 4-12, 14-19, and 21-28 were examined in the Office Action of May 30, 2003. Claims 1-2 and 4-11 have been cancelled, so that claims 12, 14-19 and 21-28 remain pending.

As applied to the non-cancelled pending claims, claim 14 is rejected under 35 U.S.C. § 103(a) over *Cuchiaro et al.* (U.S. Patent No. 6,165,802) in view of *Chivukula et al.* (U.S. Patent No. 6,146,905). Claims 12 and 15-19 are rejected under 35 U.S.C. § 103(a) over *Cuchiaro* in view of *Chivukula* and further in view of *Chu et al.* (U.S. Patent No. 6,287,637) and *Izuha et al.* (U.S. Patent No. 6,060,735). Claims 21-28 stand rejected over *Cuchiaro* in view of *Chu* and *Chivukla*.

Reconsideration and withdrawal of these rejection are respectfully requested in view of the above amendment and the remarks which follow.

A. Objection to Claim 4 addressed.

The objection to claim 4 is mooted by the cancellation of claim 4. In addition, claim 14 has been amended to correct an obvious grammatical error.

B. Obviousness Rejection of Claim 12 over *Cuchiaro, Chivukula* and *Chu* Addressed.

The rejection of claim 12 is based on the following premises:

> In re claims 11 and 12, Cuchiaro et al. in view of Chivukula et al. teach all limitations with the exception of crystallizing the ferroelectric film under a reduced total pressure (claim 11) in a range between 1 Torr and 40 Torr (claim 12).
>
> However, Chu et al. teaches in an analogous art of forming PZT ferroelectric film teach crystallizing the PZT ferroelectric film under a reduced oxygen partial pressure atmosphere (col. 6, lines 41-47) in the range of 10-4 to 100 Torr (col. 7, line 28).

Claim 12 has been amended above to further distinguish over the references and now includes the following limitation:

> such that peeling of the ferroelectric film is substantially reduced.

No new matter has been added by this amendment, support for which is found in the Summary of the Invention at page 11, lines 15-16.

Chu is silent regarding PZT film peeling or a specific range of pressure to prevent peeling. Thus, there is no motivation for a person skilled in the art to combine the teachings of *Chu* with *Cuchiaro* and *Chivukula* to select the specific claimed pressure range of 1 to 40 Torr.

Of course it is fundamental that all claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981 (C.C.P.A. 1974) Moreover, and consistent with *In re Woodruff*, 919 F.2d 1575 (Fed. Cir. 1990), the criticality of the claimed range has been shown with the unexpected results reflected in the substantially reduced peeling of the ferroelectric film.

Accordingly, claim 12 is patentably distinguishable over the combination of cited references and allowable under 35 U.S.C. § 103(a).

C. Obviousness Rejection of Claim 14 over *Cuchiaro* and *Chivukula* Addressed.

The rejection of claim 14 is based, in part, on the following premises:

> In contrast, Cuchiaro et al. do not expressly teach that the atmosphere for crystallizing [in an ambient] contains an oxidizing gas with a fraction of 1 to 20% in volume.
>
> However, Chivukula et al. in an analogous art of forming PZT ferroelectric film teaches crystallizing the PZT ferroelectric film in an oxidizing atmosphere containing O2/O3, wherein the O3 is an oxidizing gas and has a concentration in the range of 0.5 to 12% (col. 7, lines 6-10 and 29-35).

As now amended, claim 14 contains the following limitation:

> crystallizing said ferroelectric film by applying a thermal annealing process in an atmosphere containing an inert gas and an oxidizing gas with a fraction of 1 to 20% in volume;

No new matter has been added to claim 14. Support for the amendment to claim 14 is found throughout the specification and particularly in the Summary of the Invention at page 11, lines 4-8. Both O2 and O3 are oxidizing gases and thus the new limitation of an inert gas and an oxidizing gas atmosphere is neither taught nor suggested by *Chivukula*, alone or in combination with *Cuchiaro*.

Furthermore, neither *Cuchiaro* nor *Chivukula*, nor the combination thereof teaches or suggests the feature of controlling the supply of O2

> . . . to cause an oxidation in said Ti atoms that have reached a surface of said lower electrode from said layer part containing Ti atoms. . .

as recited in claim 14. Thus, *Chuchiaro* and *Chivukula*, whether alone or in combination, are silent regarding the migration of the Ti atoms to the surface of the lower electrode or oxidation of the Ti atoms once migrated.

For these reasons, claim 14 as amended is patentably distinguishable over the combination of references cited.

D. Obviousness Rejection of Claim 15 Addressed.

The rejection of claim 15 is based on the same contentions as discussed above with respect to claim and also on the following premises:

> Cuchiaro et al. in view of Chivukula et al. do not teach that the PZT ferroelectric film has a columnar microstructure extending from an interface between said lower electrode and said PZT ferroelectric film is in a direction substantially perpendicular to a principal surface of said lower electrode.
>
> However, Izuha et al. (Figs. 1-7) in an analogous art teach the claimed semiconductor device, comprising a semiconductor substrate 1; a lower electrode 4 provided over the semiconductor substrate 1; a ferroelectric film 5 on said lower electrode 4 (Fig. 1), said ferroelectric film 5 (perovskite structure such as PZT; col. 4, lines 52-53) having a columnar microstructure extending from an interface between said lower electrode 4 and said ferroelectric film 5 (Fig. 4A) in a direction substantially perpendicular to a principal surface of said lower electrode 4 (col. 2, line 57 through col. 3, line 45), said ferroelectric film 5 essentially consisting of crystal grains having a generally uniform grain diameter of less than about 200 nm (col. 6, lines 52-53); and an upper electrode 6 provided on said ferroelectric film 5; wherein said lower electrode 4 comprises a Ti layer and a Pt layer (col. 4, lines 37-45).

However, claim 15, as amended, includes the following limitation:

> said PZT ferroelectric film generally having a <111> orientation extending continuously from a bottom surface of said PZT ferroelectric film to a top surface of said PZT ferroelectric film and consisting of crystal grains generally having said <111> orientation and a substantially uniform grain diameter of less than about 200nm.

No new matter has been added to claim 15. Support for this amendment is found throughout the specification and particularly in drawing FIGS. 7A and 7B.

It must be noted that the ferroelectric film in *Izuha* is BST, not PZT. Thus, the BST film of *Izuha* causes growth in the <001> orientation or <100> orientation. *Izuha* is silent regarding growth in the <111> orientation, although this is taught in the PZT film of *Chu*. Due to the difference in growth orientations, there would be no motivation for a person of ordinary skill in the art to combine the teachings of *Izuha* and *Chu*.

Furthermore, *Izuha* teaches a columnar microstructure for a ferroelectric film wherein the size of the columnar grains is preferably in the range from 5 to 500 nm.

In addition, it should be noted that FIG. 4A of *Izuha* is a schematic diagram described at column 5, lines 18 *et seq.* and is not intended to represent the relationship of actual grain diameter distribution. It is deemed clear from the description in *Izuha* that FIG. 4A is intended to show the existence of columnar crystal structure in the lower electrode 4, the STO ferroelectric film 5 and the upper electrode 6. There is no intention in *Izuha* to show that the columnar crystals in FIG. 4A have the substantially same diameter. It is impossible that the structure of FIG. 4A, in which the grain diameter is exactly the same among the crystals constituents of the ferroelectric film, to appear in an actual ferroelectric capacitor.

Thus, *Izuha* alone or combined with the other cited art, neither teaches nor suggests the limitation to amended claim 15 recited above under which

> said PZT ferroelectric film generally having a <111> orientation <u>extending continuously from a bottom surface of said PZT ferroelectric film to a top surface of said PZT ferroelectric film</u> and consisting of crystal grains generally having said <111> orientation and a substantially uniform grain diameter of less than about 200nm.

For these reasons, claim 15 as amended is patentably distinguishable over the combination of cited references and is therefore allowable.

E. <u>Rejection to Claim 21 is Over *Cuchiaro, Chu* and *Chivukula* Addressed</u>.

The rejection of claim 21 is based on the following premise:

> *Cuchiaro* do not teach crystallizing the amorphous PZT film in an atmosphere containing a non-oxidizing gas and an oxidizing gas;

and after the crystallizing step performing an oxidizing treatment in an oxidizing ambient.

However, Chu et al. in an analogous art teach steps of crystallizing the amorphous PZT in an ambient of non-oxidizing gas (Ar) and an oxidizing gas (O2) followed by oxidizing the PZT film (Figs. 2a-2d and col. 7, lines 14-16, 29-32).

Furthermore, Cuchiaro et al. in view of Chu et al. teach that the oxygen partial pressure is in the range of 10-4 to 100 Torr (col. 7, lines 25-28; col. 8, lines 55-57; Chu). With a small amount of oxygen (col. 7, lines 11-16, Chu) in the Ar/O2 ambient, it also inherently teaches that the oxygen (oxidizing gas) is within a fraction of 1 to 20% in volume.

Claim 21 has been amended to add the following limitation:

. . . after said step of crystallizing said PZT ferroelectric film, of oxidizing said ferroelectric film in an oxidizing atmosphere such that the density of pinholes formed in said ferroelectric film in said crystallizing step is reduced.

No new matter has been added to claim 21. Support for this amendment is found throughout the specification and particularly at page 19, lines 4-8.

As was explained in the previous response filed in this case, *Chu* teaches facilitating Pb diffusion in the PZT film by intentionally inducing oxygen defects in the PZT film, while the present invention solves the problem of PZT film peeling caused by oxidation of Ti atoms that have migrated to the surface of the lower electrode from a Ti-containing layer located underneath the lower electrode. In order to achieve this object, as was previously explained, is to use the claimed pressure range of 1 to 40 Torr. Thus, there is no motivation for a person having ordinary skill in the art to combine the teaching of *Chu* with *Cuchiaro* and *Chivukula* to reach the specific fraction of the oxidizing gas of 1 to 20% as claimed.

Furthermore, the new limitation regarding the reduction of pinholes is not taught or suggested in *Chu*, or in the combination with the other cited references, since *Chu* is silent regarding the existence of pinholes in the ferroelectric film or decreasing the density of pinholes as a result of an oxidizing step conducted after the crystallizing step as claimed.

For these reasons, claim 21 as amended is patentably distinguishable over the combination of *Chu* with *Cuchiaro* and *Chivukula*.

F. Dependent Claims.

In addition to the patentably distinguishing features of independent claims 12, 14, 15, and 21 discussed above, the remaining dependent claims 16-19 and 22-28 contain further limitations and are believed allowable as depending from allowable base claims. The case is now deemed to be in condition for allowance.

G. Conclusion.

For the reasons given above, all pending claims 12, 14-19 and 21-28 are now believed to be in form for allowance and such action is respectfully requested. Should any issues remain, the Examiner is kindly asked to telephone the undersigned.

Although no fee are believed due for this filing, please charge Deposit Account No. 50-1123 any fee deficiency associated herewith.

Respectfully submitted,

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